Use of ICT in Smart Cities. A practical case applied to traffic management in the city of Valencia

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Use of ICT in Smart Cities. A practical case applied to traffic management in the city of Valencia

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***Abstract*—The whole process of converting a city into the new concept of Smart City implies the improvement of the efficiency and quality of services made available by governments and businesses and a corresponding increase in citizens' quality of life.**

This process requires a series of actions that include data collection, processing and use of this information for its dissemination among citizens. For example, it is necessary to promote the use and reuse of information from the government or private entities as open data and therefore made more useful and appropriate for citizens. Technologies such as sensor networks, ubiquity, connectivity infrastructure-vehicles and others, become essential elements to achieve this goal.

In this paper we present some relevant aspects related to these lines of action in a Smart City and their application to the traffic management data in the city of Valencia.

***Index Terms*— Information and Communications Technology, Linked Open Data, Smart City, Traffic Management.**

I. Introduction

THE cities with high concentration of population in urban areas require a great effort for the management of resources and infrastructure, so it is necessary to address the needs of citizens and provide solutions to problems in areas coordinated by local administrations.

Multiple actors have proposed different lines of action focused on the following aspects:

- infrastructure management and public buildings,
- efficient and sustainable transport,
- urban planning,
- citizen information and participation mechanisms.

However, despite the variety of areas of interest, a common element is the search for an effective and efficient management of resources and services, increasing their quality. The Smart Cities initiative combines various technologies to reduce dangerous environmental impact and provide citizens with a better quality of life [1].

Achieving these objectives undoubtedly entails finding technological solutions which come from several sectors we might call traditional, such as energy, construction and transport, as well as from the ICT sector (Information and Communications Technology).

The role of ICTs, however, goes beyond providing technological solutions in connectivity initiatives that require data processing. According to the Smart Cities and Communities Work Programme, the participation of citizens is considered a key element in Smart Cities [2],[3], as one of its main aims is to give the citizen voice and power of decision.

In those considered as Smart Cities, digital devices allow interoperability among Internet Services, the Internet of Things and the Internet of People.

In this line, the paper "Apps for Smart Cities Manifesto" [4] states that "*to achieve the true potential of the Smart Cities city should become a platform, a facilitator for developers and applications. Thus, the city resembles Internet as a link and catalyst [...] to give power to the people* ".

Moreover, the network formed by multiple devices, becomes a service that must be managed and, simultaneously, a resource that can be exploited to analyze and provide solutions to the needs of citizens. In order to exploit these two potentials as a tool for participation and as a resource in a Smart City, it is necessary to use the following:

- data provided by the existing infrastructure (by publishing data openly),
- the installation of sensor networks,
- the participation of citizens through applications on their mobile devices. The additional information provided by the citizens could complement what has already been collected but must then be tested and verified.

A particular challenge in Smart Cities is to manage multiple data sets, mostly unstructured or difficult to handle. Such sets use proprietary formats and don't follow any particular standards. Linked Open Data paradigm [5] facilitates the user with seamless access to heterogeneous services offered by Smart Cities.

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In this paper some relevant aspects of the main priorities in a Smart City are reviewed, and the particular application of these priorities to the management of traffic data in the city of Valencia is explained. First, some factors are taken into account in the use of ICT for Smart Cities and then some applications are presented, one of them having already been implemented and the other one still at proposal stage.

II. Use of ICT in Smart Cities

The use of ICT in a smart city involves four main phases related to the flow of information.. Figure 1 shows a diagram in which the flow of information is represented. The phases are discussed below:

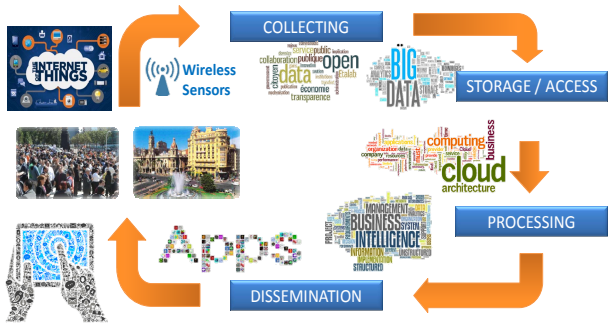

Fig. 1. Information Flow Diagram using TICs in a Smart City.

A. Collecting information

Management systems in a Smart City need access to information about the city status in order to be able to carry out adequate decision making. Currently, the main sources of information are as follows:

- The infrastructures of the city. The information is obtained by means of the mechanisms already in place (through their own infrastructure monitoring systems), but also through the introduction of new sensors, especially wireless ones, because they allow us to obtain geographically located the measurement events thanks to GPS Geo-location. The increasingly frequent connectivity in many elements, known as the Internet of Things, also provides a source of data from the infrastructure.
- Citizens through various channels. Thanks to the increasing use of mobile devices, it is possible to obtain information on social networks, or via mobile applications. The use of surveys and participation forums on the Internet are also common for data acquisition and information of citizens.

B. Storage and Data Access

The existence of a Sensors Network provides significant challenges in managing the information gathered. The efficient use of data by citizens or actors, (administrations, enterprises, management systems, ...), is based on the selective access to the information of interest and, if necessary, to the entire data set.

The efforts concerning the storage and access to data in Smart Cities should pursue the following objectives:

- having decentralized repositories of information, that hold data relevant to the area where the user is located,
- define and use data standards that are public,
- using standard communication protocols, enabling the development of client applications,
- labeling and use of metadata to recognize and categorize the meaning of the information,
- establishing an appropriate regulatory framework and licensing to ensure access to information by citizens, following the philosophy of Open Data [5].

C. Dissemination of information

Once the information has been collected and processed, it should be made available to citizens. The type of information that is received can be configured by users while current technologies allow the use of not only mobile devices but also embedded systems in vehicles or new elements such as glasses or smart watches.

One of the main challenges in this regard is the creation of systems for multi-device access based on standard web technologies, which exploit the data shared by the municipalities and their citizens, offering them high quality services closer to their needs.

III. Applications Based on ICT .

Some ICT applications for the city of Valencia are shown below:

A. Traffic characterization using wireless sensors

Urban traffic management requires detailed knowledge of the state and behavior of the traffic area of interest. Dynamic origin - destination matrices (ODM) are fundamental to road traffic management parameters.

In recent years the application of Bluetooth devices (BT) or Wi-Fi is being extended as a source of information for obtaining traffic data [6], [7].

Bluetooth sensors are unaffected by light or weather conditions and their deployment has a low economical cost. One of the drawbacks for the use of this technology is the penetration of these devices among citizens; not all cars are equipped with BT devices, and not all travelers have a device (mobile phone) that can be detected by these sensors. However, in practice this is not a problem, since it has been proven that if we have a level of penetration of 25-30% of this technology, the resulting ODM provide 95% of reliability [8].

Mobility Strategy, in the city of Valencia, has developed a pilot project based on this type of sensor which aims to analyze mobility in the urban area of the city. The devices are

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located on two traffic signal poles in one of the main streets withthe highest traffic density. The equipment allows the identification of one vehicle in different areas when it approaches the sensor. Thus, the vehicle can be subsequently located at any point in the network where the sensors are placed, to obtain travel time and origin-destination matrices. Figure 2 shows one of the installed sensors.

Fig. 2. Sensor device developed by LISITT and installed in Valencia.

A new intelligent transportation system equipment has been installed next to the electromagnetic loops located on the road, to facilitate a future comparison between the data obtained by each one of the systems.

The data collected by sensors developed in LISITT (Integrated Laboratory of Intelligent Systems and Technologies of Traffic Information, IRTIC) [9] are sent to the VLCI "Valencia Ciudad Inteligente " platform.

The VLCI digital platform has been designed by Telefonica for the City of Valencia, which becomes the first Spanish city to centralize all municipal information through a pioneer technological solution based on the European standard FI-WARE [10].

Following the strategy of smart cities, it has also been decided to make available the data from the VLCI platform for users which will lead to new developments. At present 66 data sources are available with an API for developers that allows the free use of this data under Creative Commons licence [11].

B. Connected cars. A proposal for intelligent parking management

According to a study published by *Analysis Mason* titled "Cars Online: global trends, forecasts and strategy between 2014 and 2024" [12], by 2024, 89% of new cars sold worldwide are expected to have embedded connectivity. According to the report, the technology that is being developed and will be developed for the manufacture of connected cars will be an "essential part" in the Internet of Things. Drivers demand to continue using Internet services, sending messages even when they are driving. Apple and other large companies are already working in this direction, and more recently Google has implemented an interface for vehicle connectivity.

In this sense, the interconnection of vehicles to the network information offered by this kind of cities becomes extremely important.

The fact that drivers are well informed at any time and place, effectively increase safety and traffic flow in a city or surrounding area.

Since very recently there is a clear trend towards full connectivity among vehicles or between vehicles and infrastructures. The smartphone market is shifting to the use of such on board devices.

However, most current road traffic solutions are highly user-dependent solutions, and in most cases they are not customized or contextualized to the dynamic vehicle data in real time.

On the one hand, trying the driver not to be distracted becomes a handicap to overcome, and on the other hand, the integration of vehicle information and user should allow more precise information to be obtained from the network of open information that floods our environment.

Aspects such as geolocation, data enrichment, voice recognition, text to speech conversion, open data and open platforms for the production of dynamic vehicle data are some emerging technologies and other widely used but not as an integrated solution.

A gap has been detected in the market, related to applications that allow the driver to have access to information from different sources, via voice, contextualized and personalized by adding data obtained dynamically from the vehicle to the user queries. Figure 3 shows the general architecture of the proposed system:

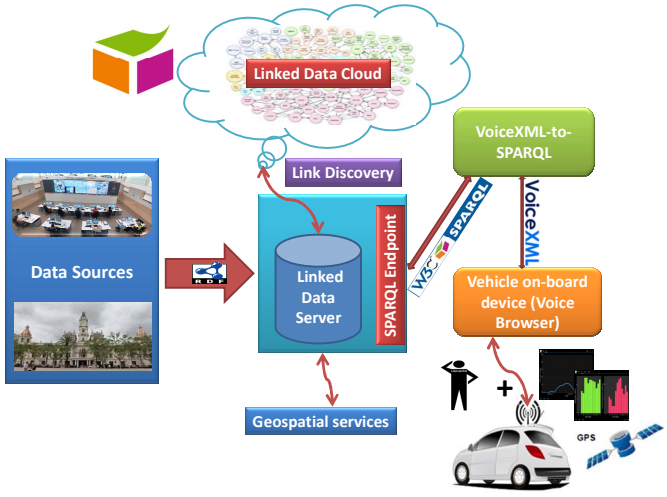

Fig. 3. A proposal architecture based on LOD.

For example, a particular application of this architecture might be searching for free parking spaces based on geographical proximity (see figure 4):

For this, it is necessary to send static information of our car (sizes and special characteristics) and vehicle dynamics information captured at the time of the query. With this elaborated query, the system will be able to obtain from its knowledge base, matching parking spaces and car profiles with additional user´s requirements (preferred floor, spaces for disabled people, two or more free adjacent parking spaces etc.).

If requested it should be possible for the driver to be guided

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by navigation systems to the parking spaces.

This would avoid having to enter any car park that does not really meet the requirements but that actually does have free parking spaces,because it would provide the location of free parking spaces suitable to my needs in response to my current status (location, autonomy, etc.).

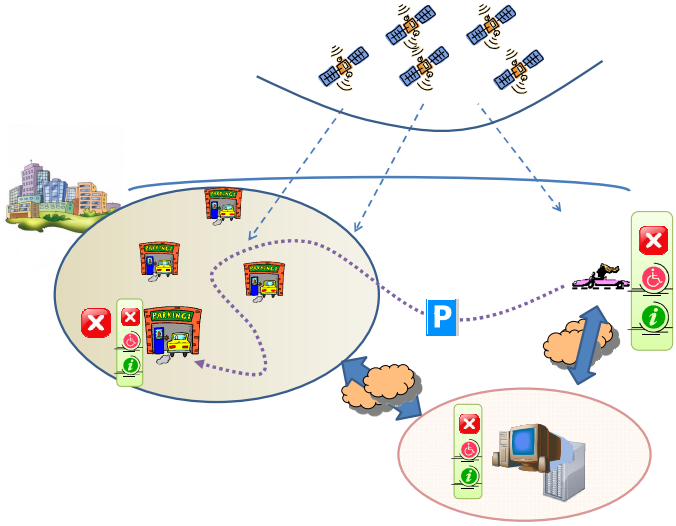

Fig. 4. Use Case: Management and guidance of / to free spaces in parking.

This proposal (see figure 3) aims to encourage the use and reuse of information from the government or private entities to make it more useful and appropriate for drivers.

The requirements are the following:

- The system should ensure the introduction of user queries through speech, so as to avoid driver distraction, and to keep his/her hands on the steering wheel [13].
- The system must allow custom queries, so that the dynamic data of the vehicle may be an essential part of its formulation.
- The system must be able to translate the spoken inquiry after adding the dynamic vehicle information, to the appropriate format to allow access to open data sources (i.e. SPARQL query language [14]) and once the response is obtained, the translation in the reverse order.

IV. CONCLUSIONS

In this paper we have reviewed the main steps that appear in the flow of information in a Smart City and we have shown a couple of applications, one of them has already been implemented and the other one is still a proposal.

We have emphasized the importance of using ICT in the management of the Smart Cities and the importance of the administrations releasing data for their use in different applications deployed in such cities.

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